PLANT CHARACTERISTICS AND CHROMOSOME NUMBERS OF FOUR RECIPROCAL CROSSES IN *DENDROBIUM*

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James McConnell

Thesis Committee:

Haruyuki Kamemoto, Chairman
Richard W. Hartmann
Roy K. Nishimoto

We certify that we have read this thesis and that in our opinion it is satisfactory in scope and quality as a thesis for the degree of Master of Science in Horticulture.

THESIS COMMITTEE

Chairman

ABSTRACT

Progenies of four sets of reciprocal crosses in *Dendrobium* were compared. Reciprocal matings of amphidiploid *D.* Jaquelyn Thomas did not differ in floral characteristics.

In reciprocal crosses of *D. strebloceras* and *D. canaliculatum*, offspring with *D. canaliculatum* cytoplasm produced more pseudobulbs and were taller in the greenhouse.

In a reciprocal cross of two *D. canaliculatum* accessions, offspring with 'D173-2' cytoplasm were taller, produced more pseudobulbs, and had higher yields. All offspring were diploids with 2n = 38. Cytoplasmic inheritance may be the cause of the differences.

Reciprocal crosses of *D. schulleri* x *D.* Sunset differed in flower quality and in chromosome numbers. Two offspring of *D. schulleri* x *D.* Sunset were triploid with 2n = *ca*. 57. Ten offspring of *D.* Sunset x *D. schulleri* were diploids with 2n = *ca*. 38.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

I. INTRODUCTION

Dendrobium Swartz, which comprises over 1000 species in 41 sections, is one of the largest genera in the family Orchidaceae (Hawkes, 1965). Numerous intra- and inter-sectional *Dendrobium* species have been reported (Sander, 1946; Sander and Wreford, 1961; Royal Hort. Soc., 1972). Intersectional hybrids involving the sections *Phalaenanthe* and *Ceratobium* have been particularly important for cut flower production in Hawaii because of their high yields, wide seasonal flowering, long vase life, and low bud drop (Kamemoto, et al., 1974).

Intersectional species hybrids generally exhibit low fertility due to lack of complete homology of parental genomes (Kamemoto, et al., 1964; Wilfret and Kamemoto, 1969). However, by doubling the chromosome number of intersectional hybrids, fertile amphidiploids may result (Kamemoto and Wilfret, 1971). These amphidiploids have been assuming considerable importance in the University of Hawaii's dendrobium breeding program (Kamemoto, et al., 1974).

The cytoplasm present in a hybrid is determined by the species used as the female parent. Therefore, a specific genome combination could be produced with different cytoplasms (Jinks, 1964; Grant, 1975). Generally it is assumed that the cytoplasm plays no major role in determining the phenotype of a hybrid (Sage, 1976). However, differences in reciprocal hybrids have been found, especially with interspecific and intergeneric crosses. Kihara (1979) reported that the cytoplasms of *Aegilops* spp. and *Triticum* spp. had specific effects on the expression of various genotypes. Some of the characters that are affected are pollen fertility, plant vigor, and flowering date (Kihara, 1979).

Recently the University of Hawaii released a new cultivar, *Dendrobium* Jaquelyn Thomas 'Uniwai Supreme' (Kamemoto and Kunisaki, In Press). This is a seed propagated hybrid of two different amphidiploid clones of *D.* Jaquelyn Thomas, 'K44-50' and '2085-4N'. The cross, 'K44-50' x '2085-4N', was evaluated, but not the reciprocal. Both reciprocal crosses were released to the dendrobium growers of Hawaii as *D.* Jaquelyn Thomas 'Uniwai Supreme'.

Preliminary investigations of an intraspecific cross, *D. canaliculatum* 'D173-2' x *D. canaliculatum* 'D129' and the reciprocal have shown considerable differences in growth depending on which was used as the female parent. Also progenies from reciprocal crosses between *D.* Sunset and *D. schulleri* have shown marked differences in horticultural characters. These dissimilarities have caused concern that reciprocal crosses may not always be equal in orchids.

The purpose of this study was to compare the performances of four hybrid progenies and their reciprocals, and to determine the cause of any differences that might occur.

II. LITERATURE REVIEW

According to Jinks (1964), there are two different mechanisms by which reciprocal crosses may produce unequal progeny: 1) irregular chromosome transmission during gametogenesis resulting in unreduced or polyploid gametes, and 2) modification of phenotype by inheritance of extra-chromosomal factors.

Irregular Chromosome Transmission in Orchids

Meiosis may vary from its usual course and produce other than haploid daughter cells. This can lead to production of diploid and tetraploid gametes (Storey, 1956). Storey suggested five pathways which could lead to formation of the unreduced gametes:

1) failure of first division with equational separation at second division;
2) failure of first division and formation of a restitution nucleus after an equational second division;
3) normal first division with recombination of second division products;
4) doubling of chromosomes in pollen mother cell followed by two normal divisions;
5) doubling of chromosomes in pollen mother cell with no meiotic division occurring.

The unreduced gametes occur more frequently in microsporogenesis than megasporogenesis. This is due to a lack of cytokinesis occurring between first and second division of microsporogenesis, whereas in megasporogenesis there is cell wall formation between divisions. Cell wall formation reduces the possible number of pathways by which meiosis may deviate (Storey, 1953; Wirth and Withner, 1959).

Dendrobium phalaenopsis 'Lyon's Light No. 1' has been extensively studied due to its abnormal breeding behavior. When Lyon's Light No. 1 was used as a female parent the morphological characteristics of the progeny were intermediate between the parents. When used as a male parent, Lyon's Light No. 1 produced offspring more similar to Lyon's Light No. 1 than the other parent (Dorn and Kamemoto, 1962). Dorn and Kamemoto (1962) and Kamemoto and Tara (1968) concluded that the unequal reciprocal hybrids were due to irregular chromosome transmission. Restitution of nuclei during microsporogenesis resulted in the formation of a large percentage of dyads. When Lyon's Light No. 1 was used as the pollen parent, triploids were produced through the functioning of unreduced pollen. Thus the triploid offspring received two genomic doses of Lyon's Light No. 1 and one dose of the female parent. When Lyon's Light No. 1 was used as a female parent, the offspring were predominantly diploid.

Extrachromosomal Factors

According to Sage (1976), the effect of the cytoplasm has generally been ignored during the genetic improvement of a crop except in cases where cytoplasmic male sterility has been utilized. In sexually reproducing organisms, a zygote forms by the fusion of a male and female gamete. Usually zygotes receive equal contributions of chromosomal genetic material (except as noted above). Contrarily, the female parent often contributes much of the cytoplasm. Still, it is generally assumed that there are no differences in the progenies of reciprocal crosses. However, there are increasing numbers of cases in which the reciprocal hybrids are not equal (Caspari, 1948; Grun, 1976). These reciprocal differences are thought to be produced by three different modes: maternal inheritance, dauermodification, and true cytoplasmic inheritance (Caspari, 1948; Jinks, 1964; Grant, 1975).

Maternal inheritance occurs when the female parent produces a substance that influences the developing embryo. This can modify the phenotype of the offspring. The most common example is found in the pond snail, *Limnea peregra* (Grun, 1976). The direction of the winding of the snail shell is controlled by the genotype of the maternal parent and not by the genotype of the offspring. The expression of the genotype of the offspring is delayed one generation. Therefore, after several generations of breeding, a maternally inherited trait will show true Mendelian ratios.

Dauermodification is used to describe the case in which a change in phenotype is induced by environmental conditions (Grant, 1975). This effect is demonstrated in the bean, *Phaseolus vulgaris*. If bean plants are treated with chloral hydrate the leaves develop abnormalities such as increase in number of leaflets (Hofmann, 1927). Upon selfing the plants, Hofmann found that the abnormality was transmitted maternally, and not by the pollen. Hofmann theorized that the factor was transmitted by the cytoplasm of the egg cell. He also found that the abnormalities decreased with each generation and showed that dauermodifications were not stable effects.

Correns was the first to investigate cytoplasmic inheritance (Caspari, 1948; Kihara, 1979). Correns crossed *Cirsium oleraceum* which had a gynoecious form and *Cirsium canum* with no gynoecious forms. In the F_1 offspring were all female. After six generations of backcrossing to the male parent, the offspring were still completely female. This indicated that the character was stable and followed non-Mendelian inheritance.

Many different characters have been found to be affected by foreign cytoplasm. The most commonly affected character is male sterility, but many morphological characters can be modified by introducing a genotype into a foreign cytoplasm. In maize, Khehra and Bhalla (1976) found that reciprocal hybrids were significantly different in plant height, ear length, ear girth and days to silk.

They repeated the crosses for several generations and found the modifications to be stable.

One of the most extensive studies of cytoplasmic inheritance has been done in wheat (Kihara, 1951; Kihara and Tsunewaki, 1962; Mukai and Tsunewaki, 1976; Dhaliwal, 1977; and Kihara, 1979). Kihara (1979) first reported effects of cytoplasm in 1940. He studied the effects by using successive backcrosses to substitute wheat genomes into various foreign cytoplasms. Various characters were measured and the offspring were compared to determine whether the cytoplasm had an effect on the expression of a genotype. The characters affected were: pollen fertility, plant vigor, date of flowering, and an increase in formation of haploids.

III. MATERIALS AND METHODS

The following four sets of reciprocal crosses in <u>Dendrobium</u> were available for this study:

1) <u>D</u>. Jaquelyn Thomas 'K44-50' x <u>D</u>. Jaquelyn Thomas '2085-4N' and the reciprocal cross;
2) <u>D</u>. <u>canaliculatum</u> 'D173-2' x <u>D</u>. <u>strebloceras</u> 'D38-3' and the reciprocal cross.
3) <u>D</u>. <u>cananliculatum</u> 'D173-2' x <u>D</u>. <u>canaliculatum</u> 'D129' and the reciprocal cross.
4) <u>D</u>. Sunset x <u>D</u>. <u>schulleri</u> and the reciprocal cross.

<u>D. Jaquelyn Thomas 'K44-50' x D. Jaquelyn Thomas '2085-4N' and the reciprocal cross</u>

'K44-50' x '2085-4N' and its reciprocal have been released to the dendrobium growers first as 'UH232' and more recently as 'Uniwai Supreme' (Figure 1; Kamemoto and Kunisaki, In Press). 'K44-50' x '2085-4N' was evaluated earlier, but the reciprocal was not. To determine whether the reciprocal crosses produced similar progenies, reciprocal crosses were made on September 20, 1975, germinated on January 8, 1976, transflasked on March 21, 1976, compotted on March 4, 1977, transplanted into two inch pots in tree fern medium on November 1, 1977, and transplanted to six inch shallow cement pots on August 8, 1978.

In addition to the reciprocal crosses, <u>D</u>. Jaquelyn Thomas 'Y166-1' (parent of 'K44-50') x <u>D</u>. Jaquelyn Thomas

Figure 1. Dendrobium Jaquelyn Thomas 'Uniwai Supreme'.

'K241-5' (a selfed offspring of '2085-4N') and _D_. Jaquelyn Thomas 'K241-5' x _D_. Jaquelyn Thomas 'K44-50' which were included to determine whether the different, but related parents would cause appreciable differences among progenies.

A randomized complete block design with four treatments and ten replications was used. Ten plants of each cross were grown in a saranhouse and a greenhouse, giving a total of forty plants in each location. The light intensity was approximately 3400 foot candles in the greenhouse and 9600 foot candles in the saranhouse. The temperatures ranged from 18^{o}C (64^{o}F) to 33^{o}C (91^{o}F) in the greenhouse and ranged from 15^{o}C (59^{o}F) to 32^{o}C (89^{o}F) in the saranhouse.

Recording of data was initiated when the plants began to flower in July, 1978. The length of the scape was measured as the distance from the bottom of the spray (raceme) to the lowest flower. The total length of the spray was measured from the base of the spray to the tip of the opposite end of the spray. Percentage bud drop was determined from the ratio of number of dropped buds or flowers to the total number of flowers. Flower width was determined by measuring the broadest measurement of the third lowest flower of the spray. The height of the plants was determined by measuring from the base to the shoot apex of the tallest growth as of May, 1980. Yield was measured as the total number of sprays produced by the plants from July, 1978 to May, 1980.

The sprays were harvested when three quarters of the flowers were open and were tested for keeping quality. Sprays were harvested between 8:00 a.m. and 11 a.m. and were immersed in tap water for fifteen minutes and then placed in 500ml flasks filled with tap water. The water was changed three times a week. At each water change, approximately three to five millimeters were removed from the base of the raceme. The sprays were kept in an air-conditioned laboratory at approximately 23^{O}C (74^{O}F) and 50% relative humidity. The sprays were recorded as wilted when half of the flowers had senesced, or the entire spray had wilted.

Analysis of variance for a randomized complete block design and Bayes Least-Significant Difference for Multiple Comparison Testing were used to analyze the data for height, yield, scape length, spray length, flower width, and keeping quality.

D. canaliculatum 'D173-2' x D. strebloceras 'D38-3' and the reciprocal cross

The intersectional cross between D. canaliculatum of the section Eleutheroglossum and D. strebloceras of the section Ceratobium was registered as D. Autumn Lace (Wilfret and Kamemoto, 1979).

A new accession of D. canaliculatum, 'D173-2', from Papua New Guinea with erect and sturdy inflorescences was used to remake D. Autumn Lace. Reciprocal crosses were made on August 8, 1975, germinated on November 11, 1975, transflasked on March 15, 1975, transplanted to two inch pots on May 23, 1977, and transplanted to four inch cement pots on September 8, 1978 (Figure 2).

This intersectional hybrid combination frequently displays heavy bud drop, which is an undesirable characteristic. The effect of cytoplasms of two species from different sections on the expression of bud drop, as well as other floral characteristics was examined.

Fourteen plants of each cross were placed on a bench using a completely randomized design. The experiment was carried on concurrently in a greenhouse and a saranhouse with light intensities and temperatures described previously.

Data were analyzed by the student's t-test. The percentage bud drop was analyzed by using arcsine transformations.

D. canaliculatum 'D173-2' x D. canaliculatum 'D129' and the reciprocal cross

Reciprocal crosses between *D. canaliculatum* 'D173-2' and *D. canaliculatum* 'D129' were made on May 13, 1975, the seed was germinated on July 14, 1975, transflasked on November 11, 1975, transplanted to compots on April 24, 1976, and transplanted to two inch pots on January 24, 1977. Differences in performance between the crosses were noticed during the two inch pot stage. Plants were transplanted to four inch clay pots in number 3 crushed rock, and were

Figure 2. Dendrobium Autumn Lace.

placed in a greenhouse as a paired experiment. The plants were paired according to size. Data was recorded beginning in January, 1979. Data were taken on height of pseudobulbs, yield, number of flowers per spray, number of pseudobulbs, scape length, and spray length. All characters were measured as described earlier. The data were analyzed by the paired student's t-test.

Somatic chromosome counts were made to rule out differences in chromosome number as the cause of the morphological differences. The root tips were sampled between 9:00 a.m. and 10:00 a.m. and were pretreated four hours in 0.002 molar 8-hydrozyquinoline solution at approximately 18°C. The root tips were fixed in a 1:1:2 mixture of 95% ethanol, chloroform, and glacial acetic acid for 12 minutes at 9°C. One normal HCl was used to hydrolyze the root tips for ten minutes at 50°C. The root tips were stored in 45% acetic acid. One per cent aceto-orcein was used to stain the smears.

D. schulleri x D. Sunset and the reciprocal cross

A commercial dendrobium breeder made a cross of two diploid plants, *D. schulleri* x *D.* Sunset which turned out to be an excellent progeny, with several offspring receiving the Award of Merit. Because of the results, the breeder repeated the combination, but inadvertently made the reciprocal cross. The progeny of the second cross turned out to be inferior, with none of the offspring producing award quality flowers.

Ten plants of the second cross were examined to determine the somatic chromosome numbers. Two of the awarded plants of the first cross were also examined for somatic chromosome numbers. The cytological method used was that described previously. No morphological data were taken for these reciprocals.

IV. RESULTS AND DISCUSSION

Dendrobium Jaquelyn Thomas

Height. The mean height of the plants at the age of 53 months from germination is shown in Tables 1 and 2. The height, expressed as the tallest pseudobulb, was not different between the reciprocal crosses K44-50 x 2085-4N and 2085-4N x K44-50 in both the greenhouse and saranhouse. The progeny of K241-5 x K44-50, however, was taller than the reciprocal hybrids in both locations. The plants grown in the greenhouse were taller than those in the saranhouse for all four crosses.

Yield. The yields of the reciprocal crosses, K44-50 x 2085-4N and 2085-4N x K44-50 were similar in both the saranhouse and greenhouse (Tables 1, 2). The highest yield was obtained for K241-5 x K44-50 in the greenhouse. In the saranhouse the yields of both K241-5 x K44-50 and Y166-1 x K241-5 were higher than that of one of the reciprocals, K44-50 x 2085-4N but not the other.

The yields of the progenies of three of the crosses was higher in the greenhouse than the saranhouse (Table 3). The yields of the reciprocal hybrids increased similarly between the greenhouse and the saranhouse, and reflected their genetic similarity.

Scape Length, Spray Length, and Number of Flowers per Spray. The scape length and spray length did not differ among the four crosses in the greenhouse (Table 1).

Table 1. Mean values of characters in matings of amphidiploid *D.* Jaquelyn Thomas in the greenhouse.

Character	Cross			
	K44-50 x 2085-4N	2085-4N x K44-50	Y166-1 x K241-5	K241-5 x K44-50
Height (cm)	121.4a[z]	114.8a	128.9ab	146.1b
Yield[y] (No. sprays)	7.2ab	7.5ab	6.3a	8.9b
Scape length (cm)	19.1a	19.0a	18.7a	18.8a
Spray length (cm)	50.1a	52.7a	54.0a	55.9a
Number of flowers per spray	14.2a	14.7ab	16.2ab	16.7b
Flower width (cm)	6.2a	6.1a	6.1a	6.5a
Keeping quality (No. days)	13.8a	14.4a	13.5a	12.8a
Percentage bud drop	0.2	0.1	0.7	0.2

[z]Mean separation within the rows by Bayes Least-Significant Difference for multiple comparison (P = 0.05).

[y]Mean number of sprays per plant over twenty-two months.

Table 2. Mean values of characters in matings of amphidiploid *D*. Jaquelyn Thomas in the saranhouse.

Character	Cross			
	K44-50 x 2085-4N	2085-4N x K44-50	Y166-1 x K241-5	K241-5 x K44-50
Height (cm)	69.9a[z]	72.7a	85.1b	85.3b
Yield[y] (No. sprays)	3.7a	4.5ab	6.2c	5.8bc
Scape length (cm)	18.6b	17.0a	17.3ab	17.1a
Spray length (cm)	48.8a	49.5a	47.4a	46.7a
Number of flowers per spray	13.4a	13.61a	14.2a	13.7a
Flower width (cm)	7.1a	6.8a	6.7a	6.8a
Keeping quality (No. days)	10.9a	9.7a	10.0a	10.2a
Percentage bud drop	2.0	1.5	1.6	0.7

[z]Mean separation within the rows by Bayes Least-Significant Difference for multiple comparison (P = 0.05).

[y]Mean number of sprays per plant over twenty-two months.

Table 3. Significance of differences between mean values of characters of _D_. Jaquelyn Thomas in the saranhouse and greenhouse.[z]

Character	Cross			
	K44-50 x 2085-4N	2085-4N x K44-50	Y166-1 x K241-5	K241-5 x K44-50
Height (cm)	+**	+**	+**	+**
Yield[y] (No. sprays)	+**	+*	+ns	+*
Scape length (cm)	+ns	+*	+*	+*
Spray length (cm)	+ns	+ns	+**	+**
Number of flowers per spray	+ns	+ns	+*	+*
Flower width (cm)	-**	-**	-**	-*
Keeping quality (No. days)	+ns	+ns	+ns	+ns
Percentage bud drop	-ns	-ns	-ns	-ns

[z]+ indicates an increase in value from saranhouse to greenhouse; - indicates a decrease in value from saranhouse to greenhouse; ** significant t-test (P = 0.01); * significant t-test (P = 0.05); ns indicates no significant difference.

[y]Mean number of sprays per plant over twenty-two months.

However, in the saranhouse the scape length of one of the reciprocal hybrids, K44-50 x 2085-4N was slightly longer than that of the other reciprocal hybrid 2085-4N x K44-50 and K241-5 x K44-50 (Table 2). The number of flowers per spray was similar for the reciprocals in both locations. In the greenhouse, cross K241-5 x K44-50 had a higher number of flowers per spray than K44-50 x 2085-4N. The values of all three characters were generally higher in the greenhouse than the saranhouse (Table 3).

Flower Width. The flower widths were similar for all crosses in both the greenhouse and the saranhouse (Tables 1, 2). However, the flower widths were greater in the saranhouse than the greenhouse (Table 3). This was the only morphological character showing an increase in the saranhouse over the greenhouse. The greater number of flowers per spray and the higher yields in the greenhouse plants may have been responsible for reducing the size of the flower.

Keeping Quality. The keeping quality was not different among the crosses in either the greenhouse or saranhouse. The flower sprays harvested from the greenhouse plants kept longer than the flower sprays harvested from the saranhouse by at least two days; however, this was not a significant difference.

Percentage Bud Drop. The mean percentage bud drop values were less than one percent for all four crosses in the greenhouse (Table 1), and two percent or less in the saranhouse (Table 2). The higher bud drop in the saranhouse was probably due to environmental factors. The saranhouse grown plants were exposed to excessive moisture from frequent rains during the night giving cool, damp conditions. This caused outbreaks of *Botrytis cinerea* frequently resulting in dropping of buds and flowers. No disease symptoms were observed in the greenhouse.

Effect of the Environment. The greenhouse produced larger, higher yielding plants with more flowers per spray than the saranhouse. This indicates that the greenhouse was superior to the saranhouse for dendrobium cut flower production.

The greenhouse, which was shaded with white paint, had a much lower light intensity than the saranhouse. The light intensity was reduced approximately 74% from full sun in the greenhouse whereas in the saranhouse there was approximately a 30% reduction. On a clear day in July 1979, the plants received 3000 to 3400 foot candles in the greenhouse and 9400 to 9600 foot candles in the saranhouse.

The minimum and maximum temperatures for the first six months of 1980, in the greenhouse, were a low of $18^{o}C$ ($64^{o}F$) and a high of $33^{o}C$ ($91^{o}F$). In the saranhouse, the low temperature was $15^{o}C$ ($59^{o}F$) and the high was $32^{o}C$ ($89^{o}F$). Both day and night temperatures were higher in the greenhouse. Also, the difference between day and night temperatures was less in the greenhouse.

In both locations plants were watered three times per week. However, plants in the saranhouse were exposed to more moisture due to frequent rains, which resulted in a high incidence of disease. Botrytis Blight of flowers and leaf spots caused by Phyllostictina pyriformis were troublesome in the saranhouse. On the other hand, the greenhouse plants showed no symptoms of diseases. The saranhouse plants rapidly dropped the leaves of their pseudobulbs while the greenhouse plants retained most of theirs. Botrytis cinerea probably caused the higher percentage bud drop in the saranhouse.

Insects were more difficult to control in the saranhouse. Pesticides were rapidly washed off due to the frequent rains. Orchid weevils caused the most damage. The larvae burrow into the pseudobulbs, and the adults damage young growths, growing points, and young flower buds. Some orchid weevil damage occurred in the saranhouse.

The lower light and higher temperatures probably caused the increased vegetative growth in the greenhouse compared to the saranhouse. The excessive height is an undesirable feature. The plants in the saranhouse were shorter and lower yielding due to a combination of factors. The higher light intensity and lower temperatures would result in shorter plants. In addition, the plants in the saranhouse were also under stress due to the disease and insect problems. This combination of factors would reduce yield and growth.

Preliminary Conclusions. With the exception of scape length in the saranhouse, the reciprocal crosses, K44-50 x 2085-4N and 2085-4N x K44-50, did not show variation in either the saranhouse or the greenhouse, indicating their genetic similarity and lack of cytoplasmic influences. Thus the reciprocals released to the dendrobium growers as D. Jaquelyn Thomas 'Uniwai Supreme' (Kamemoto and Kunisaki, In Press) can be expected to be uniform.

The other two crosses, Y166-1 x K241-5 and K241-5 x K44-50 did not always give similar values with each other or the reciprocal crosses. Both of these crosses exhibited some differences. Cross K241-5 x K44-50 had higher values for practically all of the characters in the greenhouse. One disadvantage of this cross might be the excessive height of the plants when grown in the greenhouse.

The yields obtained thus far represent early yields. Further testing of the progenies is required to better evaluate the performance of the four crosses.

D. canaliculatum 'D173-2' x D. strebloceras and the reciprocal cross

Two of the characters evaluated, height and number of pseudobulbs differed in the reciprocal crosses grown in the greenhouse (Table 4), but not in the saranhouse (Table 5). The progeny in the greenhouse with D. canaliculatum cytoplasm (D173-2 x D38-3) were taller and had an increased

Table 4. Mean values of characters in reciprocal crosses of *D. strebloceras* 'D38-3' and *D. canaliculatum* 'D173-2' in the greenhouse.

Character	Reciprocal Cross: D38-3 x D173-2	Reciprocal Cross: D173-2 x D38-3	t value[z]
Number of pseudobulbs	16.6 ± 1.34	22.4 ± 2.09	2.3*
Height (cm)	29.4 ± 1.79	38.9 ± 2.70	2.9**
Yield[y] (No. sprays)	9.9 ± 1.71	13.1 ± 1.76	1.3ns
Scape length (cm)	16.0 ± 0.58	15.1 ± 0.41	1.29ns
Spray length (cm)	33.6 ± 0.97	32.8 ± 1.11	0.57ns
Number of flowers per spray	18.7 ± 0.78	18.6 ± 0.52	0.94ns
Earliness to flower[x] (months)	8.9 ± 1.25	8.8 ± 1.31	0.08 ns
Percentage bud drop	40.7 ± 11.21	37.1 ± 11.47	0.20ns

[z]** Student's t-test significant (P = 0.01); * Student's t-test significant (P = 0.05); ns indicates no significant difference.

[y]Mean number of sprays per plant over sixteen months.

[x]Months consecutively numbered from January, 1979.

Table 5. Mean values of characters in reciprocal crosses of D. *strebloceras* 'D38-3' and *D. canaliculatum* 'D173-2' in the saranhouse.

Character	Reciprocal Cross: D38-3 x D173-2	Reciprocal Cross: D173-2 x D38-3	t value[z]
Number of pseudobulbs	11.1 ± 0.89	12.2 ± 1.01	0.80ns
Height (cm)	26.2 ± 2.01	25.9 ± 1.56	0.10ns
Yield[y] (No. sprays)	15.4 ± 2.17	16.0 ± 2.34	0.20ns
Scape length (cm)	14.5 ± 0.49	13.8 ± 0.45	1.02ns
Spray length (cm)	33.1 ± 1.08	31.5 ± 1.16	1.60ns
Number of flowers per spray	21.2 ± 0.98	19.1 ± 0.57	1.01ns
Earliness to flower[x] (months)	5.9 ± 0.90	4.9 ± 0.70	1.80ns
Percentage bud drop	41.9 ± 9.61	22.5 ± 7.63	1.56ns

[z]ns indicates no significant difference.

[y]Mean number of sprays per plant over sixteen months.

[x]Months consecutively numbered from January, 1979.

number of pseudobulbs. None of the other characters differed significantly at either location. However, while there were no other significant differences at the 5% level, a similar pattern was noticed in both the greenhouse and saranhouse. Progeny with *D. canaliculatum* cytoplasm showed a tendency toward earliness to flower and higher yields. On the other hand, the progeny with *D. strebloceras* cytoplasm (D38-3 x D173-2) showed a tendency for increased scape length, total length of spray, and number of flowers per spray and bud drop, an undesirable character.

Due to the relatively small numbers of individuals available, it was not possible to obtain conclusive evidence. However, in view of the same pattern of increases and decreases of each character in both locations, the cytoplasm might have an influence in this intersectional hybrid. In order to determine this, repeated backcrossing to the parents would be desirable. Also, more individuals should be included. If there is a real difference due to the origin of the cytoplasm, then from a horticultural standpoint the *D. canaliculatum* cytoplasm producing a greater number of pseudobulbs and higher yields and showing a tendency toward shorter inflorescences, earlier flowering, and lower bud drop would be the preferred female parent.

D. canalciulatum 'D173-2' x D. canaliculatum 'D129' and the reciprocal cross

The reciprocal crosses of *D. canaliculatum* showed

Table 6. Mean values of characters in reciprocal crosses involving *D. canaliculatum* 'D173-2' and *D. canaliculatum* 'D129'.

Character	Reciprocal Cross: D129 x D173-2	Reciprocal Cross: D173-2 x D129	t value[z]
Height (cm)	7.1 ± 1.01	10.9 ± 0.71	4.32**
Number of pseudobulbs	9.8 ± 0.57	16.1 ± 1.44	4.29**
Yield[y] (No. sprays)	4.0 ± 0.63	7.6 ± 1.52	2.62*
Scape length (cm)	14.1 ± 0.63	14.3 ± 0.53	0.53
Spray length (cm)	23.7 ± 2.04	27.1 ± 1.66	1.38
Number of flowers per spray	18.5 ± 1.97	23.6 ± 1.41	2.30

[z]**t-test significant (P = 0.01); * t-test significant (P = 0.05); ns indicates no significant difference.

[y]Mean number of sprays per plant over sixteen months.

Figures 3-4. Comparison of offspring of the cross, *D. canaliculatum* 'D129' x *D. canaliculatum* 'D173-2', and the reciprocal cross.

Figure 3--An offspring of the cross *D. canaliculatum* 'D129' x *D. canaliculatum* 'D173-2'.

Figure 4--An offspring of the cross *D. canaliculatum* 'D173-2' x *D. canaliculatum* 'D129'.

large differences in height of plants, number of pseudobulbs, and yield (Figs. 3-4;Table 6). The differences in scape length, spray length, and number of flowers per spray were not significant, although the number of flowers per spray approached the 5% level of significance. The higher values for the characters were obtained in offspring with 'D173-2' cytoplasm.

Chromosome counts of the progenies did not deviate from $2n = 38$, the expected number of the species.

The difference in performance of the reciprocal crosses suggests cytoplasmic effects.

D. schulleri x D. Sunset and the reciprocal cross

The reciprocal crosses differed in chromosome number. The two offspring of the cross *D. schulleri* x *D.* Sunset were determined to be triploid with chromosome counts of $2n = 56$, and 58 (Table 7). The reciprocal cross *D.* Sunset x *D. schulleri* produced all diploid offspring with chromosome counts of $2n = 38$ and *ca*. 39 (Table 7). This indicates that one of the parents was producing unreduced gametes. The suspected parent is *D.* Sunset because unreduced gametes are more commonly found in pollen than in egg cells, and *D.* Sunset was the male parent in the cross producing the triploid offspring. The offspring of the *D. schulleri* x *D.* Sunset cross more closely resembled *D.* Sunset than *D. schulleri* (Fig. 5).

These results are similar to those obtained by Dorn and Kamemoto (1962) with *D.* 'Lyon's Light No. 1'. When *D.*

Table 7. Chromosome numbers of selected offspring of *D. schulleri* x *D.* Sunset and the reciprocal cross.

Cross	Offspring number[z]	Chromosome number[y]
D. schulleri x *D.* Sunset	1	56*
	2	58*
D. Sunset x *D. schulleri*	1	38
	2	39*
	3	39*
	4	38
	5	38
	6	38
	7	38
	8	38
	9	38
	10	38

[z]Offspring number designates an individual plant.

[y]* indicates an approximate count of ± one chromosome.

Figure 5. Comparison of flowers of reciprocal crosses of D. schulleri and D. Sunset. Left: A flower from an offspring of the cross D. Sunset x D. schulleri. Right: A flower from an offspring of the cross D. schulleri x D. Sunset.

'Lyon's Light No. 1' was used as the pollen parent, offsrping produced were predominantly triploid. The triploid offspring resembled *D.* 'Lyon's Light No. 1' more than the female parent. Restitution of nuclei during meiotic divisions in microsporogenesis produced the unreduced gametes. Resulting triploids showed a prepotency of *D.* 'Lyon's Light No. 1'. This was due to the triploid offspring receiving two genomes from *D.* 'Lyon's Light No. 1' and only one genome from the female parent.

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